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STATISTICAL STUDIES ON VARIATION IN THE WING-LENGTH OF A BUTTERFLY OF THE SUBFAMILY SATYRINÆ.

BY T. FUKUDA.

As is well known, the distinction of sex, generation, or habitat in any species of butterfly may sometimes be a definite cause of the differences in size. The aim of the present report is to determine statistically the degree of such differences found under these circumstances.

MATERIAL.

Ypthima philomera var. *argus*, which I selected for the material of this work, is a small butterfly of the subfamily Satyrinæ commonly found in Japan. Judging from my observations and breeding experiments, this species most likely repeats its life-cycle three times during one year, at least in all the warmer districts of this country, the butterflies appearing in succession, April–May (first generation), June–July (second generation), and August–October (third generation). The details of the material are shown in Table I.

TABLE I.

Lot.	Male.	Female.	Date.	Locality.[1]
I	37	....	11–15, V, 1910	Kawanabé, Prov. Satsuma.
II	42	....	13–17, VII, "	" " "
III	57	36	20–24, IX, "	" " "
IV	53	30	20–24, VIII, 1909	Himeji, Prov. Harima.
V	45	....	28–30, VIII, 1910	" " "
VI	157	56	19–22, VIII, "	Tsumago, Prov. Shinano.

All the individuals of one and the same lot were captured by myself within an area about two miles in diameter. There is scarcely any doubt that Lots I–III belong to the corresponding generations of 1910, while Lots IV and V are most likely the representatives of the third. Having come from a comparatively cold district, Lot VI probably consists of the individuals of the second generation.

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[1] Kawanabé, Prov. Satsuma, 20 miles south of Kagoshima, nearly at the southern extremity of Kiushiu; Himeji, Prov. Harima, 35 miles west of Kobé; Tsumago, Prov. Shinano, 60 miles northeast of Nagoya.

THE METHOD OF MEASUREMENT.

The method adopted in the measurement is as follows: the right fore wing of the butterfly, carefully removed from the body, is put upon the glass stage of a dissecting microscope and covered with a thin plate of mica; the mirror of the microscope is arranged to so reflect light from its surface as to make the outline of the wing clear; then the length from the base of the wing to the farthest point on its outer margin, without taking the length of the marginal hairs into account (this point is always a little behind the anterior angle), is measured with compasses from over the mica to the nearest half-millimeter.

THE DIFFERENCES AMONG THE MEANS.

Table II shows how the variants of each lot are distributed through the classes, while in Table III are exhibited the means of measurements, the standard deviations, and the coefficients of variation with their probable errors. One may notice in these tables, but more clearly in Table IV, how some fairly considerable differences occur among the mean values of several measurements. These differences are always great enough to be considered significant, as they exceed three times the corresponding probable errors except in one case only (*a*) where two groups of males from the same locality and captured in the same season two successive years are to be compared with each other. It might be supposed that some intrinsic causes lying in the bodies of the animals must have had influence in determining the wing-length of the butterflies; but several external factors, too, *e.g.*, the temperature, the quantity of food, etc., working on the developing organisms surely have had some important share in it.

TABLE II.

Lot	Sex	No.	CLASS.												Mode.	Range.
			15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0		
I	♂	37	....	....	....	....	1	3	2	6	9	9	5	2	19.5, 20.0	17.5–21.0
II	♂	42	....	....	....	1	10	13	12	5	1	....	....	....	18.0	17.0–19.5
III	♂	57	1	1	5	16	20	11	3	....	....	....	....	....	17.5	15.5–18.5
III	♀	36	....	3	10	13	8	2	....	....	....	....	....	....	17.0	16.0–18.0
IV	♂	53	....	1	3	6	16	17	9	1	....	....	....	....	18.0	16.0–19.0
IV	♀	30	1	2	5	13	4	4	1	....	....	....	....	....	17.0	15.5–18.5
V	♂	45	....	....	1	6	13	16	9	....	....	....	....	....	18.0	16.5–18.5
VI	♀	157	....	....	1	1	11	29	50	37	22	4	2	....	18.5	16.5–20.5
VI	♀	56	....	....	2	4	9	22	7	8	3	1	....	....	18.0	16.5–20.0

TABLE III.

Lot.	• Sex.	No.	Mean.	Standard Deviation.	Coefficient of Variability.
I	♂	37	19.527 ± 0.093	0.838 ± 0.066	4.29 ± 0.34
II	♂	42	18.155 ± 0.057	0.551 ± 0.041	3.03 ± 0.22
III	♂	57	17.360 ± 0.053	0.591 ± 0.037	3.40 ± 0.21
III	♀	36	16.944 ± 0.057	0.511 ± 0.041	3.01 ± 0.24
IV	♂	53	17.717 ± 0.057	0.611 ± 0.040	3.45 ± 0.23
IV	♀	30	17.050 ± 0.080	0.650 ± 0.057	3.81 ± 0.33
V	♂	45	17.789 ± 0.051	0.511 ± 0.036	2.87 ± 0.20
VI	♂	157	18.637 ± 0.036	0.667 ± 0.025	3.58 ± 0.14
VI	♀	56	18.116 ± 0.067	0.738 ± 0.047	4.07 ± 0.26

TABLE IV.

	Lots.	Difference.	%
a	V -IV ♂	0.072 ± 0.076	0.405
b	I -II	1.372 ± 0.109	7.026
c	II -III ♂	0.795 ± 0.078	4.379
d	VI ♂-II	0.482 ± 0.067	2.586
e	VI ♂-V	0.848 ± 0.062	4.550
f	V -III ♂	0.429 ± 0.074	2.412
g	III ♂-III ♀	0.416 ± 0.078	2.396
h	IV ♂-IV ♀	0.667 ± 0.095	2.795
i	VI ♂-VI ♂	0.521 ± 0.076	2.796

We can see (Lots I–III in Tables II, III, or *b*, *c* in Table IV) that the length of the fore wings of the male butterflies diminishes gradually as the season advances.

That this species winters over as caterpillars was ascertained in my breeding experiments, and that Lot I implies only the individuals which had hibernated during their caterpillar stages is scarcely doubtful, so I am inclined to attribute this difference (*b*) of the wing-length between this lot and Lot II to some such cause as mentioned by Standfuss,[2] *i.e.*, the difference in the length of the feeding period, which had happened to affect the developing organisms. The same rule has probably held in Case *c*. In the succeeding three cases, *d–f*, we can recognize how the length of the fore wings of the butterflies, even if of the same sex and generation, has the tendency to increase the more the latitude of their habitat increases.

Bachmetjew[3] has ascertained that the butterflies of this subfamily flying in Bulgaria, with a few exceptions, have greater wing-expansion than those of the same species found in Germany or in France. He attributes this to the difference of temperature. We have several other instances concerning the size of the butterflies of this subfamily diminishing gradually under comparatively high latitudes. All these instances are not in accordance with my result. In *g–i* once more we meet with such an instance of the differences in the wing-length as is opposed to the facts hitherto commonly acknowledged and especially to the results of observations made by Bachmetjew. On examining ten Bulgarian species of this subfamily, he has concluded that the wing-expansion of the females more or less exceeds that of the males. The case is quite the reverse with *Ypthima philomera* var. *argus,* the males having on an average longer fore wings than the females. It is true that this species shows a sexual difference in the shape of the fore wings, their anterior angles being a little more obtuse in females than in males; but this difference is never so great that it can reverse the situations of the two sexes. I cannot interpret the above-mentioned discrepancies between the present results and those hitherto obtained but to attribute them to the differences between the species.

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[2] Morgan, T. H., *Experimental Zoology*, 1907, pp. 24, 25.

[3] *Experimentelle Entomologische Studien*, II (1907).

THE STANDARD DEVIATIONS AND THE COEFFICIENTS OF VARIABILITIES.

The standard deviations and the coefficients of variation do not represent anything as distinct as the case of means. They are fairly great, however, in Lot I, differing so much from those of Lot II or III as to claim to be considered probably significant; thus:

σ the difference between Lots I and II
0.287 ± 0.077

σ the difference between Lots I and III
0.247 ± 0.076.

C the difference between Lots I and II
1.26 ± 0.40

C the difference between Lots I and III
0.89 ± 0.40

If we call to mind that the individuals included in Lot I are such as had distinctly longer caterpillar stages than in the other lots, this fact may deserve our special notice.